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A device and a process for coarsely grinding hydrous polymer gels

The present invention relates to a device for crushing a hydrous polymer gel, comprising two rolls located axially parallel and rotating in opposite directions between which a nip for the passage of the polymer gel is formed. The present invention further relates to a process for carrying out coarse grinding.

Aqueous polymer gels are obtained from water-soluble monomers by means of solution polymerization in the production of water-soluble or water-swellable polymers. Industrial manufacturing processes for water-soluble polymers are known. These polymers are used as flocculation aids, dewatering and retention agents, as viscosity-increasing agents in aqueous media, for example, in tertiary oil recovery, or as grinding aids and dispersing agents. Manufacturing processes for the production of water-swellable polymers are also known; these polymers are used as superabsorbers in the hygienic and sanitary field, as soil conditioners in agriculture, or as sealants in the production of current-conducting and light-transmitting cables.

In general, the powder products are manufactured in a continuous process, for example, by radical polymerization of water-soluble polymers on an endless belt, as described in DE 35 44 770 C2, wherein hydrous polymer gels in soft, viscoplastic, or brittle state are obtained after polymerization.

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Processing the polymer gels into powders is carried out in the subsequent stages of crushing, fine reduction, drying, and grinding; high effort is required if the polymer properties achieved in the gel state are to be maintained. A uniform process sequence, which is also required for this purpose, is already impaired by preliminary

disintegration and comminution of the soft, viscoplastic, or brittle gels. For example, viscoplastic gel blocks or gel strands are torn to pieces of irregular size in kneaders, whereas size reduction of soft gels results in pieces of increasing dimensions with increasing plasticity, and the kneaders are frequently blocked by coiled gel pieces.

This results in a nonuniform material flow causing different layer thicknesses in screen belt drying and an insufficient or excessive drying of the polymer, which impairs the subsequent grinding and classifying process; on the other hand, keratinization of the polymer, for example, results in reduced solubility or swellability and therefore in performance loss of the product.

Moreover, when brittle crosslinked gels having a cross-linker content of more than 0.15%, relative to the total amount of monomers, are processed large amounts of excessively small gel particles are formed in conventional processing, and these reduce the yield of dry product in the required particle-size range, for example, of 1,000 - 3,000 μm, after drying and grinding.

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To avoid the described drawbacks, particle-shaped polymers having a high molecular weight and good solubility are produced according to DE 35 06 543 C2 such that the polymer sheeting having a maximum layer thickness of 10 mm is first cut into strips having a width of 3 mm to 10 mm in a roller-type cutting device by means of a pair of rollers; their surface is provided with a plurality of annular projections or grooves arranged at given distances and they rotate in opposite directions. These strips are then cut into cubical pieces with a side length of 3 mm to 10 mm by means of a combination consisting of a stationary blade and a rotary cutting unit. The rotary cutting device has a pivoted cylindrical body whose circumference is provided with at least one blade.

According to the process of DE 35 06 543 C2 it is necessary to adjust the polymer concentration in case of acrylamide polymers in the range of 20 to 60%-wt., and in case of cationic polymers, which in particular form homopolymers having a very soft consistency, the monomer concentration to 50 to 85%-wt. To obtain gels in a processable state, it is further necessary according to this process to apply nonionic or anionic surface active agents on the polymer film, to blow in cold air so as to embrittle the gel mass by cooling, and, optionally, to predry the polymer film at 50 - 120°C by means of hot air. Because of the cutting knives' arrangement the described process additionally requires an exact polymer layer thickness after polymerization. The mentioned process conditions require a great deal of expenditure with respect to both appliance and technique, which means cost.

It is accordingly the object of the present invention to find an improved device for coarse grinding hydrous polymer gels which permits uniform and inexpensive size reduction of soft, viscoplastic, or brittle polymer gels, as well as to develop a process which is suitable for uniform and inexpensive processing of aqueous polymer gels having different consistencies.

In order to achieve this object the present invention proposes to improve the device of the above-mentioned kind such that one roll is formed as a cutting roll which is provided with at least one axially extending cross cutting element having a cutting edge and with a radially extending longitudinal cutting element provided with a cutting edge which runs around it, and that the other roll is formed as a back-up roll.

The advantage of a device for crushing a hydrous polymer jelly which is formed according to this technical teaching is that the arrangement of cross cutting and slitting element on one roll provides a low-cost device which additionally reduces the gel in

one single step so that size reduction can be carried out in a rapid and inexpensive way.

In order to achieve the above-mentioned object the present invention further proposes to improve the device of the above-mentioned kind such that one roll is formed as a cross cutting roller which is provided with at least one axially extending cross cutting element with a cutting edge, that the other roll is formed as a back-up roll, and that a longitudinal cutting roller with at least one radially extending slitting element provided with a cutting edge revolving around it is arranged ahead of the cross cutting roller.

The advantage of a device for crushing a hydrous polymer jelly which is formed according to this technical teaching is that the outlay in equipment, as compared with the art, is comparatively low, that cutting may be carried out with one single device, that cutting may be carried out in a very rapid and inexpensive way, and that separating the longitudinal and transverse cut into two subsequent steps provides a very clean cut.

According to a preferred embodiment of the present invention the width of the roll gap approximates the height of the cross cutting and/or longitudinal cutting elements. This involves the advantage that the cutting elements adjoin the back-up roller at least at one point of their rotation, ensuring clean cutting of the polymer gel.

The roll nip is variable to allow its exact adjustment in accordance with the polymer gel to be cut and the condition of the cutting elements. The whole back-up roll may, for instance, be displaced in relation and parallel to the cutting or cross cutting roll. According to a particularly preferred embodiment the rotational speed of the longitudinal cutter is higher than the conveying rate of the polymer gel. This avoids congestion.

According to another preferred embodiment the cutting elements are formed of a flat steel provided with a polish on one side, and their cross section is preferably formed in a plane or sickle-shaped manner. Thus the cutting edge strikes the surface of the gel layer at an angle of smaller than 90° and a clean and uniform cut is achieved.

To this end it is advantageous to distribute the cross cutting elements uniformly on the circumference of the cutting roll and to arrange them in parallel or in the form of a spindle to the cutting roll's longitudinal axis.

According to a particularly preferred embodiment of the device according to the present invention the back-up roll conveys the polymer gel and presses it against the cross cutting and/or slitting elements during the cutting process. The advantage of this is that the polymer gel is transported reliably and separated properly at the intended site.

One or several longitudinal cutting elements and one or several cross cutting elements may be fitted to the cutting roller so that the polymer gel may be cut into nearly any desired size.

According to another particularly preferred embodiment the surface of the back-up roll is coated with a plastic material. This plastic is intended, on the one hand, to protect the back-up roll from wear and damage, and simultaneously to realize good adhesion of the back-up roll to the polymer gel without impairing it. To this end, it is preferable to use polyethylene, polypropylene, or Teflon.

According to another particularly preferred embodiment the surface of the back-up roll is provided with depressions. These depressions are arranged such that they are able to receive the

cutting edges of the cross cutting and/or slitting elements located on the cutting roller. This ensures that the cutting elements completely penetrate the polymer gel and effect clean separation thereof.

As another solution to achieve the above-mentioned object the present invention proposes a process for crushing hydrous polymer gels which coarsely grinds the hydrous polymer gel into polymer gel particles of given size immediately after polymerization without any auxiliary agents or additional technical measures, using a device according to the present invention ~~at least one of claims 1 to 11~~.

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This process is preferably carried out continuously.

It has been found that hydrous polymer gels of different composition and consistency, optionally immediately after polymerization, may be crushed with a device according to the present invention, without further auxiliaries or additional technical measures, into gel particles of predetermined size and be fed in a continuous flow of material to fine reduction and the subsequent processing stages of drying, grinding and classifying.

The advantage thereof lies in the fact that the process for crushing aqueous polymer gels and, in general, the working method for such polymer gels is rendered simpler and cheaper, in particular since further auxiliaries or measures become obsolete.
Whereas it is sufficient gel strength that guarantees size reduction in the known processes, the use of the device according to the present invention allows processing of soft and plastic polymer gels, for example, copolymers with a high cationic portion, cationic homopolymers, or of low-molecular polymers, provided that the aqueous polymer gels are capable of being sheared. The plasticity of the polymer gels is also of minor importance.

The method according to the present invention provides a uniform, trouble-free material flow in the following process stages, in particular during drying, grinding, and sieving the powders. In particular, the disadvantages resulting from excessive drying are avoided, and powder products of a constantly high quality are formed.

Additional advantages of the device and the process according to the present invention will become obvious from the description of the embodiments and the accompanying drawings. The above-mentioned features and those that will be described in the following may be realized according to the present invention either individually or in any combination with each other. It is understood that the mentioned embodiments do not represent a definitive listing but are intended to be illustrative. Embodiments of the present invention are shown in Figures 1 to 4 and will be illustrated in greater detail in the following.

Fig. 1 shows a perspective representation of a first embodiment of a device according to the present invention for crushing hydrous polymer gels;

Fig. 2 shows a perspective representation of a second embodiment of the device according to the present invention having two longitudinal cutting elements and three cross cutting elements uniformly distributed over the circumference;

Fig. 3 shows a third embodiment of the device according to the present invention having five longitudinal cutters and a cross cutter staggered by 60° over the length of the cutting roll;

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I ~~Fig. 4 shows a perspective representation of a fourth embodiment of the device according to the present invention, here the~~

~~cross cutting and longitudinal cutting~~ elements ~~are located on two separate rolls; and.~~

Ins E1

Fig 5 is a...

The individual Figures partially show the subject matter of the present invention in an extremely schematic view, they are not true to scale. Some objects shown in the individual Figures are extremely scaled up to elucidate their structure.

Ins E2

The first embodiment shown in **Fig. 1** is preferably used for coarse grinding soft and/or plastic hydrous polymer gels **10**. This polymer gel **10** is fed {by a conveying device 100 [102]} to the device as a gel strand **10** of a maximum thickness of 10 mm. E2 This gel strand **10** is guided in a roll nip **13** formed between a cutting roll **11** and a back-up roll **12**. The ~~longitudinal~~ circumferential cutting element **14** provided on the cutting roll **11** separates the gel strand **10** into two partial strands; the cross cutting element **15** also arranged on the cutting roll **11** separates cuboid-formed gel pieces **16** from each partial strand. The roll gap **13** is dimensioned such that the ~~longitudinal~~ circumferential cutter **14** and the cross cutter **15** with its cutting edge **17** can be guided just along the back-up roll **12** without contacting it. The same applies to a cutting edge **18** running around the ~~longitudinal~~ circumferential cutting element **14**. The cutting roll **11** in this embodiment has one single ~~longitudinal~~ circumferential cutter **14** and one single cross cutter **15**.

The roll gap **13** is adjustable so as to meet differing demands.

Fig. 2 shows a second embodiment comprising two ~~longitudinal~~ circumferential cutters **14** and three cross cutters **15** equally spaced over the circumference of the cutting roller **11**. As for the rest, this embodiment corresponds to the above-mentioned first embodiment.

This second embodiment is preferably used for crushing visco-plastic or brittle polymer gels.

The third embodiment shown in **Fig. 3** has five circumferential longitudinal cutting elements **14** and one single cross cutting element **15**. However, this cross cutter **15** is staggered on the circumference over the axial length of the cutting roller 11 by 60° each time.

The fourth embodiment shown in **Fig. 4** is provided with a cross cutting roller **19** having three cross cutters **15** distributed over its circumference and with a longitudinal cutting roller **20** which has two slitting elements **14** and is arranged ahead of the cross cutting roller **19**.
In this embodiment, the cross cutting elements **15** have a sickle-shaped cross section so that the cutting edge **18** strikes the surface of the polymer gel **10** at an angle of smaller than 90°.

Knives having a form and design which is known in principle are used as slitting elements **14**; they preferably have a disk-shaped, circular form and are made, for example, of stainless steel and are arranged on the cutting roller **11**, **20** in any desired manner or at a defined distance. The size of the circumferential longitudinal cutting elements **14** is selected such that the complete polymer gel layer is cut through in each cutting process. Polymer gels, preferably band-like gel strands, with a layer thickness in the range of 3 to 500 mm, preferably of 3 to 150 mm, and further preferred of 10 to 130 mm, may be reduced in size by means of the device according to the present invention.

As cross cutting elements **15** flat steels are used which are polished on one side and whose surface is plane or, preferably, formed such that they have a sickle-shaped profile so that the cutting edge strikes the surface of the gel layer at an angle of smaller than 90°.

The cross cutting elements **15** may be arranged on the rotating shaft at any desired radial distance, with a different or preferably

equal angular distance, in parallel, or in the form of a spindle, with respect to the rotation axis.

The size of the cross cutting elements **15** is chosen such that the polymer gels with the stated layer thickness and a width of 100 to 2,000 mm, preferably 100 to 800 mm, are separated in one operation, i.e. during one single passage of the polymer gel through the device.

The number and arrangement of the longitudinal **14** and cross cutting elements **15** is variable and depends on the properties of the polymer gel to be processed and on the desired size of the gel portions whose length ranges from 100 to 200 mm and whose width ranges from 10 to 200 mm.

Figs. 1 to **4** also show the operation of the device according to the present invention. During cutting the gel particles are obtained in a form depending on the number of longitudinal and cross cutting elements **14** and **15** and on the conveying rate of the gel strand through the device. The illustrated shapes are obtained with identical conveying rate and circumferential speed of the slitting elements **14**. To avoid congestion, however, the circumferential rate of the longitudinal cutters **14** is usually chosen to be above the conveying rate of the polymer gel strand, which is of the order of 0.05 m/min. to 1.5 m/min., and preferably in the range of 0.1 to 0.5 m/min.

According to another embodiment of the device according to the present invention, which is not illustrated, the assembly of cutting elements may be arranged on several, preferably two or three pivoted rollers. For example, the device may consist of two rollers (cf. Fig. 4), the first roll **20** preferably having at least one longitudinal cutting element **14** and the second roll **19** having at least one cross cutting element **15**.

The adhesion of gel particles to and between the cutting elements is prevented by the device according to the present invention without having to use any auxiliaries.

At least one back-up roll **12** provided with a nip **13** which is adjustable in accordance with the thickness of the gel layer to be processed is arranged in parallel to the circumferential longitudinal and cross cutting elements **14** and **15**; it transports the gel and presses it against the cutting edges **17,18** of the cutting elements **14,15** during the cutting process.

The surface of the back-up roll **12** is preferably coated with a plastic material, such as polyethylene, polypropylene, and/or Teflon, and preferably has a structure. Notches (12A) nls, wherein the cutting edges **17,18** of the cutting elements **14,15** may be guided, additionally ensure a thorough cut through the whole gel layer.
In a process according to the present invention using the device according to the present invention hydrous polymer gels of water-soluble or water-swellable homo- and copolymers or graft polymers are comminuted, preferably immediately after polymerization, into gel pieces of predetermined size which are then fed to the following fine reduction carried out, for example, in a grinder.

The mentioned hydrous polymer gels are formed by radical polymerization of water-soluble, monoolefinically and optionally polyolefinically unsaturated monomers. Examples thereof include α,β unsaturated mono- and dicarboxylic acids, such as acrylic acid, methacrylic acid, maleic acid, itaconic acid, and/or their sodium, potassium and/or ammonium salts; acrylic acid and methacrylic acid esters of aminoalkyl alcohols in quaternary salt form or as hydrosalts, such as dimethylaminoethyl (meth)acrylate-hydrochloride, dimethylaminoethyl (meth)acrylate-hydrosulfate, dimethylaminoethyl (meth)acrylate-methochloride, dimethylaminoethyl (meth)acrylate-methosulfate; acrylamide and methacrylamide and

their N-mono- and N,N-dialkyl derivatives, such as (meth)acrylamidopropyl trimethylammonium chloride, (meth)acrylamidopropyl trimethylammonium methyl sulfate, as well as N-methylol (meth)-acrylamide and its ethers partially or completely formed with C_1 to C_4-alcohols; (meth)acrylamidoalkyl sulfonic acids and/or their salts, such as 2-acrylamido-2-methylpropane sulfonic acid, hydroxyalkyl (meth)acrylates; as well as vinylsulfonic acid, (meth)-allyl sulfonic acid, (meth)allyl alcohol sulfate, vinylphosphonic acid and/or their salts; N-vinyl amides, e.g. N-vinyl formamide, N-vinyl acetamide, N-vinyl-N-methylacetamide, and N-vinyl-N-methyl-formamide, diallyl dimethylammonium chloride, N-vinylpyrrolidone, N-vinyl imidazole, N-vinyl imidazoline, 2-methyl-1-vinyl imidazoline, 2-sulfoethyl (meth)acrylate; styrene phosphonic acid and styrene sulfonic acid and/or their salts.

Examples of multiply olefinically unsaturated compounds include acrylates and methacrylates of polyols, such as butanediol diacrylate, hexanediol di(meth)acrylate, polyglycol diacrylate, trimethylolpropane triacrylate, ethoxylated trimethylolpropane triacrylate, allyl acrylate, diallyl acrylamide, triallylamine, diallyl ether, methylenebisacrylamide, and functional compounds, such as polyglycide ether, epichlorohydrin.

The mentioned monomers may be copolymerized with one another in any desired ratio.

Water-containing gels of graft polymers are obtained by polymerizing at least one of the mentioned monomers with substrates, such as starch, cellulose or its derivatives, such as carboxymethyl- or hydroxyethylcellulose, polyvinyl alcohol or polyvinyl acetate partially saponified to polyvinyl alcohol.

Examples of such polymer gels include hydrous, viscoplastic high-molecular, ionic or nonionic or amphoteric mono- or copolymers

which are used as flocculation, retention and/or thickening aids; brittle, cross linked mono- and copolymers which are used as superabsorbers for the production of hygienic, sanitary and incontinence articles, or in plant cultivation and agricultural production, for example, for soil conditioning. In case of brittle polymer gels, for example the Stokosorb®-products, the process according to the present invention reduces the fine-grain powder portion, which is disadvantageous in application, by about 20%-wt. in favor of the particle-size range of 200 - 1,000 μm.

List of reference numbers

10	polymer gel/gel strand
11	cutting roll
12	back-up roll
13	roll gap
14	longitudinal cutting element
15	cross cutting element
16	gel pieces
17	cutting edge
18	cutting edge
19	cross cutting roll
20	longitudinal cutting roll